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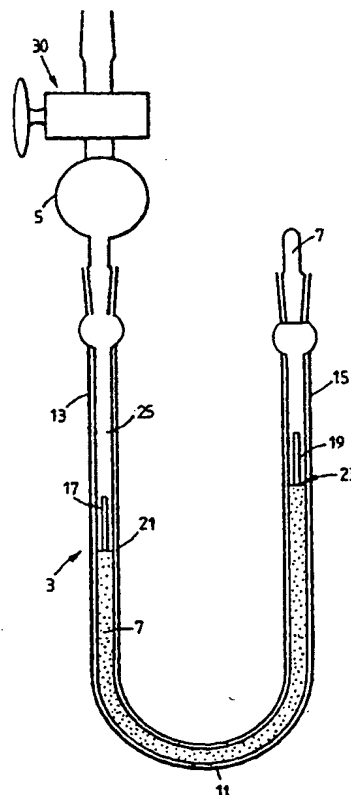
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: MAXIMUM/MINIMUM THERMOMETER

## (57) Abstract

This invention relates to maximum/minimum thermometer of the type comprising an expansion liquid, a transfer liquid and indexes for recording the maximum and minimum temperatures. Described in particular are new transfer liquids designed to replace conventionally used mercury and new indexes suitable for use in the disclosed thermometers.



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MAXIMUM/MINIMUM THERMOMETER

This invention relates to maximum/minimum thermometers.

Maximum/minimum thermometers are well known in the art and date back some two hundred years. For example that of J. Six (1731-1793) was described by him to the Royal Society in 1782.

US4,627,741 discloses a typical maximum/minimum thermometer which has an improved index recovery mechanism.

As will be appreciated maximum/minimum thermometers such as described in US4,627,741 are often constructed from a U-shaped liquid containing tube in which mercury metal is provided in the bend of the U-section and extends into the two legs of the U-tube. The mercury serves as a so-called "transfer liquid".

In addition to the mercury, the U-tube contains an expansion liquid which contacts the mercury, and is immiscible therewith. Movement of the mercury is effected by the expansion or contraction of the expansion liquid in response to changes in temperature.

Also provided are two temperature display indexes or pins contained within the U-shaped tube. In use the indexes are initially positioned so they contact and float at the surface of the mercury. Upon advancement of a mercury front, the index in contact with the advancing mercury front is moved along within the U-tube.

The indexes may be described as unidirectional devices since upon retreat of the mercury front from the index, the index retains its position in the U-tube typically by virtue of a restraining method. For example one method of restraint is provided by a magnetic attractive force between the index and a magnetic strip placed adjacent to the U-tube.

An alternative index restraining method may be provided by a frictional force between the inner wall of the U-tube and a sprung glass hair attached to the index.

By using two indexes, one at each front of the mercury, the recordal of the temperature at each extreme end of a temperature range is thus possible. One index will accord a position which represents the maximum temperature, and the other index will accord a position representing the minimum temperature observed over a particular time interval. Temperature markings are provided on a graduated scale positioned adjacent to the U-tube allowing the maximum and minimum temperatures to be read directly.

Currently however, the transfer liquid of choice is mercury metal because of its suitable physical properties such as its high density, (i.e.  $13.6\text{gcm}^{-3}$ ) and its immiscibility with many expansion liquids. Moreover mercury metal also remains liquid, over a wide temperature range (ie. mercury has a melting point of  $-38.9^{\circ}\text{C}$  and a boiling point of  $356.6^{\circ}\text{C}$ ), making it suitable for use in many maximum/minimum thermometer applications.

Notwithstanding the aforementioned suitable characteristics of mercury it is apparent, because of current heightened environmental awareness, that use of mercury in thermometers is undesirable. For instance  
5 mercury is highly toxic. Thus, mercury requires special handling and disposal procedures should spillage occur, for example through thermometer breakage. Moreover, mercury is also relatively expensive.

It is among the objects of the present invention to  
10 obviate or at least mitigate one or more of the aforementioned problems associated with thermometers which employ mercury as a transfer liquid.

It is an object of the present invention to provide a maximum/minimum thermometer comprising a transfer liquid  
15 which is substantially or more preferably entirely mercury free.

According to a first aspect of the present invention there is provided a maximum/minimum thermometer comprising an expansion liquid which expands or contracts in response  
20 to changes in temperature, a transfer liquid which is substantially immiscible with the expansion liquid, and two indexes capable of being moved through action of the transfer or expansion liquid, wherein the transfer liquid is mercury free.

It is understood that the term "transfer liquid" refers  
25 to the liquid within a maximum/minimum thermometer which is moved in response to the thermal expansion/contraction of the expansion liquid, and the purpose of which is to assist

in identifying the maximum and minimum temperatures over a particular time period, by providing a means for moving the indexes to positions indicative of the maximum and minimum temperatures.

5           The maximum/minimum thermometer may be of a typical U-tube design wherein the transfer liquid is positioned within the bend of the U-tube, extending into each leg thereof. In use, the indexes initially rest at each front of the transfer liquid. The maximum and minimum  
10           temperatures may be read off a temperature scale associated with the U-tube from the final resting positions of the indexes.

It is generally understood that the transfer liquid should have the following properties:

- 15           i) be immiscible with the expansion liquid;  
            ii) remain substantially in a mobile liquid state at and between the upper and lower temperature limits of the thermometer in use; and  
            iii) have a density which is different from that of the  
20           expansion liquid.

To ensure that the transfer liquid remains in the liquid state within any particular temperature range, the skilled addressee will appreciate that the contents of the U-tube may be pressurised accordingly. For example for any  
25           particular transfer liquid an increase in pressure will enable the liquid state to exist at higher temperatures.

Desirably the transfer liquid may also have:

- low thermal expansivity;
- display low toxicity; and
- be coloured or be capable of being coloured.

5            Depending on any particular application the skilled addressee may choose any suitable combination or all of the above-mentioned desirable properties in addition to the generally essential properties i), ii) and iii).

10           Typically the transfer liquid will have a density greater than the expansion liquid. Thus, for example, if a U-shaped maximum/minimum thermometer is used in an upright position, that is, with the legs of the U-tube directed upwards, the transfer liquid will rest below the expansion liquid traversing the bend in the U-tube and  
15           extending into the two legs. However, it should be understood that maximum/minimum thermometers may be designed which rest sideways, rather than in the upright position, or maybe of other shapes.

20           It will be appreciated that for a thermometer which is to be used in an upright position the choice of transfer liquid may be determined by the density of the expansion liquid being used. For example if toluene (density  $0.87\text{g.cm}^{-3}$ ), a typical expansion liquid, is used, the transfer liquid will have a density greater than  $0.87\text{g.cm}^{-3}$ .

25           Maximum/minimum thermometers are often used to measure a maximum/minimum air temperature for example in a greenhouse. Thus, the transfer liquid should preferably remain substantially liquid up to and above the highest



expected temperature. Therefore, the transfer liquid will generally be required to remain substantially liquid up to and above 50°C, more preferably above 70°C. It will be appreciated however that the choice of transfer liquid will ultimately depend on the application the maximum/minimum thermometer is being put to. Consequently the transfer liquid may be chosen for thermometer use at much higher temperatures for instance above 150°C.

Conversely the transfer liquid should preferably remain substantially liquid at a temperature which is below that of the lowest temperature expected to be encountered when using a maximum/minimum thermometer. Thus, for example, for outside use the substantially liquid state of the transfer liquid should be maintained preferably below -30°C, more preferably below -50°C.

The skilled addressee will appreciate that environmental ambient temperature changes generally occur slowly, and therefore this allows for a viscous transfer liquid to be used if necessary. A viscous liquid, although being mobile, will move relatively slowly. Alternatively, the transfer liquid may not be completely homogeneous, that is, it may contain suspended solid particles or droplets of liquid; such a transfer liquid may be colloidal.

Preferably the transfer liquid displays low thermal expansion. Thus, although an expansion liquid expands/contracts in response to temperature changes, it is preferable that the transfer liquid displays a low degree of expansion/contraction in response to temperature

changes. However, if the transfer liquid does display a certain degree of thermal expansion this may be taken account of by appropriate design of the temperature scale. Such a design may be a non-linear temperature scale.

5           Since the transfer liquid is moved within the U-tube by expansion/contraction of the expansion liquid, the transfer liquid must be substantially immiscible with the expansion liquid and/or display substantially no chemical interaction with the expansion liquid.

10           It is also desirable that the transfer liquid display low toxicity, or at least be considered less toxic than mercury.

          Although it is the indexes which generally serve to identify the maximum and minimum temperatures, it is preferable aesthetically that the transfer liquid is  
15           coloured or is capable of being coloured so that it may easily be seen in the thermometer. Typically the transfer liquid may be coloured by the addition of suitable dyes. Depending on the transfer liquid being used suitable dyes  
20           may include Eurocert Green S or water-soluble salts of inorganic complex ions such as the copper (II) (tetra-ammoniato) ion or the hexacyanatoferate ion. Naturally, the skilled addressee may envisage the use of other suitable dyes.

25           A suitable dye may be chosen for its preferential solubility of the dye in the transfer liquid as compared to its non-solubility in the expansion liquid.

Examples of suitable transfer liquids which possess at least some of the aforementioned preferred properties include solutions comprising inorganic or organometallic compounds, for example solutions of compounds of elements found in groups III, IV, V, VI and VII of the periodic table (see table 1 below) or mixtures thereof, as well as organic liquids, such as members of the halogenoparaffin series of compounds.

**Table 1**

Group	Possible Compounds
III	Halides of boron
IV	Halogen derivatives of silane and disilane, Mixed silicon halides and organo-halides, Many possible compounds derived from stannane substituted with halogens and alkyl groups. Organolead compounds. Titanium tetrachloride
V	Pure and mixed halides and organohalides of phosphorus. Halogen substituted derivatives or arsine and stibine
VI	Sulphur halides, some selenium and tellurium halides
VII	Some interhalogen compounds

Additionally, a recent revival of interest in molten salt chemistry has led to the exploration and development of low-melting ionic liquids. These are salt mixtures which are liquid at room temperature and examples exist which are liquid down to  $-90^{\circ}\text{C}$ . A number of possible systems already exist and many more can be envisaged. Most current knowledge relates to binary systems containing the compounds aluminium trichloride, phosphorous pentafluoride,

and boron trifluoride. When mixed with quaternary ammonium salts in which the substituents may be paraffin chains of various lengths, a range of liquid results. In such salts the quaternisable nitrogen atoms may be in rings such as pyridine or imidazole rings.

As examples it is possible to produce a series of such low-melting liquids by combining 1-alkyl-3-methyl imidazolium chloride with boron trifluoride via metathesis of the chloride of the former with sodium tetrafluoroborate.

It is envisaged that liquids having densities in the useful range mentioned in other sections of this patent can be synthesised. The melts are of low toxicity and may be coloured with standard organic dyes. Certain of the liquids may be employed in the present invention as transfer liquids along with certain of the expansion liquids chosen from those mentioned herein.

A particularly preferred transfer liquid is a solution comprising ionic compounds, typically a solution comprising at least one alkaline earth or alkali metal salt.

The solution may be an aqueous solution in which said at least one alkaline earth and/or alkali metal salt is dissolved. The solution may however comprise an organic liquid, such as an alcohol, ketone, ether or mixtures thereof.

Alkaline earth and/or alkaline metal salts are particularly preferred because of their high solubilities in water. For example it is possible to make aqueous

solutions in which the amount of alkaline earth and/or alkali metal salt is between 80% and 400% w/v, for example between 100% to 200% w/v.

5 Dissolution of the alkaline earth and/or alkali metal salt in water lowers the freezing point below 0°C. The degree of freezing point lowering will depend on the molecular weight of the solute, its percentage concentration in solution, and the number of ions into which it dissociates in aqueous solution. Each "particle" 10 in the solution contributes separately to the freezing point lowering (the Van't Hoff *i*-factor). This makes alkaline earth and/or alkali metal salts very efficient in lowering the freezing point. Using solids of such high solubility it is possible to lower the freezing point of a 15 concentrated aqueous solution to -40°C to -50°C.

Such salt solutions comprising high percentages of alkaline earth and/or alkali metal salts also have densities greater than water. For example calcium bromide solutions of 110% w/v, 120% w/v and 125% w/v have densities 20 of 1.62, 1.66 and 1.68g.cm<sup>-3</sup> respectively. The temperature at which solid precipitates from each of the solutions, either by freezing or deposit of solute is around -51°C.

25 Salt solutions such as those described herein also boil above 100°C since the dissolved substance also raises the boiling point of water in accordance with Raoult's Law. This makes the substances eminently suitable for use as the transfer liquid since the boiling point is substantially above that of the highest temperature on a typical

maximum/minimum thermometer scale.

Moreover these aqueous salt solutions are likely to have only limited self-expansion since the salt is present as ions. The expansivity will, therefore, be similar to that of water itself which, in turn, is only a little more than mercury and about a fifth that of toluene, a common thermometer expansion liquid.

If the transfer liquid is water-based there will be an interface interaction only with other liquids with which water is miscible or reacts directly. Such liquids are generally inorganic or are oxygenated organic compounds, e.g. alcohols, ketones, phenols, or, possibly, organohalogen compounds. This means that there is a range of other organic liquids which may be used as the expansion liquid, for example hydrocarbons such as toluene, xylenes, kerosene, gasoline, or their mixtures.

Additionally, dissolved alkaline earth or alkali metal salts have varying levels of toxicity but a number are essentially non-toxic and, because of the high boiling points of the solutions, have low vapour pressure. Accidental breaking of the thermometer would not, therefore, constitute a hazard and any residue could readily be flushed away with water.

Generally the alkaline earth or alkali metal salt may be selected from such compounds as halides (for example fluorides, chlorides, bromides, iodides), sulphates, hydroxides, carbonates, chlorates, dichromates, chromates, carboxylates (for example acetates), nitrates, nitrites,

phosphates, ammonium compounds or other salts comprising an alkaline earth or alkali metal ion and a cationic species.

Suitable examples of metal salts which may be used are  $\text{CaI}_2$ ,  $\text{CaBr}_2$ ,  $\text{CsBr}$ ,  $\text{CsF}$ ,  $\text{CsOH}$ ,  $\text{Cs}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOCs}$ ,  $\text{KF} \cdot 2\text{H}_2\text{O}$ ,  $\text{HCOOK}$ ,  $\text{KI}$ ,  $\text{KNO}_2$ ,  $\text{RbF}$ ,  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  or  $\text{NaI} \cdot 2\text{H}_2\text{O}$ .

Particularly preferred salts are selected from alkaline earth metal halides, such as  $\text{CaI}_2$  and  $\text{CaBr}_2$ .

Generally speaking solutions of the above-mentioned salts are colourless or only weakly self-coloured. However, colourants may be readily introduced by the use of water-soluble, non-toxic dyestuffs during preparation.

It will be appreciated that the same properties may also be achieved using mixtures of the aforementioned salts in which there is no mutual reaction.

It may also be possible to employ a high-density organic compound as transfer liquid. These are almost exclusively halogenated compounds and certain of them are toxic. If such an organic material were used, however, the nature of the expansion liquid would have to be changed to suit the interface (ie. be immiscible). Furthermore, since organic liquids generally have a high thermal expansivity, a significant correction to one side of the thermometer scale would be necessary. Mixtures of organic liquids would also be feasible and would be governed by the same principles.

Preferably however the transfer liquid will have a low thermal expansivity compared to the expansion liquid. Nevertheless to account for any small changes in volume in

the transfer liquid the temperature scale of the thermometer may be graduated in a non-linear fashion so as to correct any errors which would otherwise occur if the temperature scale was linear.

5           The present invention also in a further aspect provides the use of solutions as described herein as transfer liquids in maximum/minimum thermometers.

Desirably the expansion liquid should possess:

- i) high thermal expansivity;
- 10   ii) be substantially immiscible with the transfer liquid;
- iii) remain substantially in a mobile liquid state at and between the upper and lower temperature limits of the thermometer; and
- iv) have a density which is different to that of the
- 15   transfer liquid.

Given the above specifications, a hydrocarbon or a mixture of hydrocarbons may be used as the expansion liquid should the transfer liquid be an aqueous solution. Hydrocarbons are sharply separable from water and can be

20   mixed readily with organohalogen compounds in order to raise the density smoothly.

Hydrocarbons, such as toluene, the xylenes, kerosene, gasoline, or their mixtures and a variety of other organic compounds could be used either alone or in admixture

25   depending on the system chosen. These are cheap, readily available, and often of low toxicity. If the transfer liquid were itself organic then a different choice of expansion liquid would be necessary. An alternative choice



for this role in the latter case could be a hydroxylated/oxygenated organic compound such as an alcohol, ether, ketone, or ester or a mixture of these.

5 The indexes must be designed to function appropriately with the chosen transfer liquid and expansion liquid. Preferably the indexes should be chemically and physically stable towards both the transfer and expansion liquids.

10 Generally speaking the indexes will have a density less than that of the transfer liquid and be able to float at the surface of the transfer liquid. Such indexes are therefore moved by action of the transfer liquid. The indexes may be magnetic or rendered magnetic such that it is possible for a magnet or magnets placed adjacent or near to thermometer to hold the indexes in position. Retention  
15 of an index by the magnet occurs after retreat of the transfer liquid from said index.

For example it is possible to construct a glass-based index for the thermometer by forming a glass tube with very thin walls and inserting a small piece of ferrous wire.  
20 The overall density of the index can be pre-determined by judiciously combining the density contributions of glass, wire, and the air contained in the tube.

A suitable index may be fabricated by using a low-density tubular plastic material (e.g low or high-density  
25 polyethylene, polypropylene or other material having density in the region of  $1.0 \text{ gm.cm}^{-3}$ ) containing a piece of ferrous metal. As for the glass-based index above the dimensional parameters i.e length, diameter, and wall

thickness can be varied to produce an overall index having suitable density. The expansion liquid density can then be tuned to that of the index for buoyancy; an appropriate index may have density in the region of  $1.0 \text{ gm.cm}^{-3}$ .

5        A third type of solid index can be constructed by first synthesising a plastic with intrinsic magnetic properties. This may be done by mixing and/or melting together the chosen plastic or its components with a quantity of a magnetic powder such as iron filings,  
10       magnetite ( $\text{Fe}_3\text{O}_4$ ), strontium ferrite, or other magnetic powders. The amounts of each component may be adjusted to provide suitable magnetic strength whilst preserving a low density e.g 10 - 15% of magnetite with polypropylene produces a plastic of density  $0.98 - 1.02 \text{ gm.cm}^{-3}$ . This  
15       plastic is initially produced as a solid mass and then may be melted, extruded, or pulled out to give a fine fibre. This is then chopped to afford magnetic plastic indices. Density adjustment of the expansion liquid to suit the index density must then be carried out.

20       The magnets for use with a maximum/minimum thermometer comprising magnetic indexes generally lie behind the tube legs and the transfer liquid must be able to push the indexes along whilst they are in the magnetic field yet leave them "fixed" in position when the transfer liquid  
25       retreats. The former is generally achieved via buoyancy adjustment of the expansion liquid in a way which makes it possible to move the index along by only a small "push" of the transfer liquid. For the same reason, only a small

magnetic attraction is required to hold the index in place when the transfer liquid retreats.

It should be appreciated however that other indexes such as the type using a spring glass hair mentioned in the introduction or other frictional devices may also be used. Moreover, if the U-tube is used in a horizontal position, the indexes may not require frictional or magnetic features. The indexes have to be able to be pushed along by the transfer liquid and may be reset by tilting the thermometer upright and allowing the indexes to return into contact with the surface of the transfer liquid.

As mentioned above, the density of the index should generally be less than that of the transfer liquid so that the index will rest at the surface of the transfer liquid. However, fluid statics dictates that there will be a partial sinking of the index in the higher density surface to a depth determined by the relative densities of the two. This is generally aesthetically undesirable in a maximum/minimum thermometer but may be avoided by raising the density of the expansion liquid appropriately. This may be done by mixing into the principal expansion liquid an amount of a higher-density liquid. For example if toluene (density  $0.87 \text{ gm.cm}^{-3}$ ) is used as the main component of the expansion liquid, bromobenzene (density  $1.491 \text{ gm.cm}^{-3}$ ) or 1,3-dibromopropane (density  $1.989 \text{ gm.cm}^{-3}$ ) may be added. This increases the buoyancy of the expansion liquid and allows the index to rest on the surface of the transfer liquid.

The maximum/minimum thermometers described herein are generally formed from glass. However, suitable plastics material may also be used.

5 It has been observed that the transfer liquid may not move completely freely within the thermometer and may in some instances tend to stick to the glass. As such it may be desirable to add a friction reducing agent, such as a surfactant, to the transfer liquid.

10 The present invention will be further understood with reference to the following detailed description of "test apparatus" showing the underlying principles of the present invention and with reference to Figures 1 and 2, which shows such "test apparatus".

15 A maximum/minimum thermometer test apparatus (1) shown in Figure 1 has been constructed to demonstrate the principles given and to allow experimentation with both transfer and expansion liquids and with various index types. The apparatus (1) is of a U-shaped tube (3) design. The bore of the U-tube is 5 mm. and has at its two ends a reservoir bulb (5) (ca. 6 ml. capacity) and a stopper (7)  
20 which are removable for cleaning and re-filling.

In this example the U-tube (3) is partially filled with a transfer liquid (9) which is a 120% w/v solution in water of calcium bromide. As can be seen, with the U-tube  
25 (3) in an upright orientation, the calcium bromide solution (9) fills the bend (11) of the U-tube (3) and extends into each leg (13, 15) of the U-tube (3). The calcium bromide solution (9) can be tinted suitably with any water-soluble

dyestuff, in this case, Eurocert Green S at a level of ca. 0.05% by weight.

Two indexes (17, 19) are inserted within the U-tube (3) and rest at the two fronts (21, 23) of the calcium bromide solution (9). The two indexes (17, 19) are made from polypropylene tubing (diameter 2.3 mm., bore 0.4 mm. and length 20 mm.). A piece of iron wire (thickness 0.1 mm. and length 5 mm.) is placed inside each index (17, 19) and the ends sealed by heating and flattening. This produces an index with density near  $1 \text{ gm.cm}^{-3}$ .

The indexes (17, 19) have been "balanced" in the expansion liquid (25) i.e the density of the expansion liquid (25) has been adjusted to give buoyancy to the indexes (17, 19) so that each index (17, 19) can be raised in the limb against a magnetic field provided by magnets (not shown) by movement of the transfer liquid (9). In this example the expansion liquid (25) is mainly toluene and, in the balancing process 1,3-dibromopropane has been added drop by drop to raise the density of this liquid suitably.

A small quantity of expansion liquid (9) has been added to leg (15) of the U-tube (3) so as to cover index (19) and the stopper (7) fitted. The reservoir bulb (5) has been fitted, and the whole leg (13) and reservoir bulb (5) filled fully with expansion liquid (25) using a syringe, and the tap (30) closed.

It will be appreciated that this "test apparatus" is useful for illustrating the viability of all the principles mentioned herein.

5 The "test apparatus" described above has been tested at temperature between 13.0°C and 60.0°C using full immersion in a water bath and was observed to function appropriately.

10 In addition to the aforementioned features magnets are used to hold the indexes (17, 19) in position once moved by the transfer liquid (9). The magnets are positioned behind each leg (13, 15) of the U-tube (3) and their distance from the U-tube (3) adjusted in order to allow the indexes (17, 19) to function correctly.

15 The skilled addressee will understand that in use a temperature scale (not shown) is also provided behind the U-tube (3) so that the maximum and minimum temperatures may be read from the positions of the two indexes (17, 19) in the U-tube (3).

20 A more detailed "test apparatus", similar to a commercial maximum/minimum thermometer has also been constructed, details of which are given below:

Normal Thermometric glass is cut into suitable lengths.

25 An automatic process draws the glass and blows an expansion cavity as shown (Figure 2). The cavity is left open. A second automatic process heats the opposite end of the stem and by application of filtered air through the open ended cavity, the thermometer bulb (40) is formed.

The straight thermometer is now filled with toluene (expansion fluid) (42) in a vacuum filling process.

A reading index (44) (see specification below) is inserted into the thermometer bore and allowed to sink to the bulb (40).

An automatic process, expels the surplus toluene (42) with the bulb (40) above ambient temperature and continues to heat and bend the thermometer (46) into a U-shape.

The bore is then filled with dyed calcium bromide (transfer liquid - see specification below) (48) care being taken to deposit the calcium bromide on the surface of the toluene.

The U-shaped thermometer (46) is now inverted with bulb (40) being held above ambient temperature and surplus calcium bromide (48) is drawn off to a pre-specified distance from the base of the U-bend.

The bore and expansion cavity (49) are then manually filled with toluene (50).

A reading index (51) is inserted into the cavity and allowed to drop onto the calcium bromide surface (52).

The thermometer is then cooled below ambient and the expansion cavity (49), (which also contains air due to the contraction of the liquids used in the bore), is quickly sealed. This allows for compression of the air in the event of the thermometer being heated to a level outside its maximum working temperature.

1. Specification for Reading Indexa) Formulation

Polypropylene PP BFC 1012 Nat:100 gms

Magnetite C1312B (Avocado): 36 pph Polypropylene

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b) Compounding

Materials compounded in torque Rheometer at 180°C  
for 8 minutes and granulated using Christy Noris  
granulator.

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c) Strand Extrusion

Extrudate production is achieved using a Carter/Beher  
Acer 2000 capillary Rheometer, fitted with a capillary  
die of suitable length and diameter to produce and  
index of appropriate dimensions to suit the bore of  
the thermometer.

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d) Extrusion

The extrudate is drawn and cut using a linked Gillard  
350/30 - 1800 bench cutter to appropriate lengths.  
Density of each index approximately 1.15g/cm<sup>3</sup>.

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2. Specification of Transfer Liquid

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Formulation

120 gm Ca Br<sub>2</sub> . x H<sub>2</sub>O

38 ml Supercook Green Colouring

62 ml H<sub>2</sub>O



22

0.027 ml CF 32 (Rohn & Haas) surfactant  
Density approximately  $1.6\text{g/cm}^3$ .

The U-tube shown in Figure 2 is then mounted onto a  
suitable frame, behind which, is placed (on each limb) a  
5 strip magnet running along the length of the limb. These  
magnets retain the reading index in the position of maximum  
and minimum temperature, to which the transfer liquid  
menisci have raised them.

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CLAIMS

1. A maximum/minimum thermometer comprising an expansion liquid which expands or contracts in response to changes in temperature, a transfer liquid which is substantially immiscible with the expansion liquid, and two indexes capable of being moved through action of the transfer or expansion liquid, wherein the transfer liquid is mercury free.

2. The maximum/minimum thermometer according to claim 1 wherein the transfer liquid has a density which is different from that of the expansion liquid.

3. The maximum/minimum thermometer according to claim 2 wherein the transfer liquid has a density greater than that of the expansion liquid.

4. The maximum/minimum thermometer according to claim 3 wherein the transfer liquid has a density greater than  $0.87 \text{ g. cm}^{-3}$ .

5. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid remains in a substantially mobile state at and between the upper and lower temperature limits of the thermometer in use.

6. The maximum/minimum thermometer according to claim 5 wherein the transfer liquid remains substantially liquid at least between  $-30^{\circ}\text{C}$  and  $+50^{\circ}\text{C}$ .

5           7. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid further displays a low thermal expansivity; a low toxicity; and/or is coloured or capable of being coloured.

10           8. The maximum/minimum thermometer according to claim 7 wherein the transfer liquid is capable of being coloured by a suitable dye.

15           9. The maximum/minimum thermometer according to claim 8 wherein the dye is selected from Aniline Blue, Eurocert Green S or water soluble salts of inorganic complex ions such as the copper (II) (tetra-ammoniato) ion or the hexacyanato ferrate ion.

20           10. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid is selected from solutions of inorganic or organometallic compounds; organic liquids; and ionic liquids.

11. The maximum/minimum thermometer according to claim 10 wherein the transfer liquid is a solution comprising inorganic or organometallic compounds of elements found in groups III, IV, V, VI and VII of the periodic table, or mixtures thereof.

12. The maximum/minimum thermometer according to claim 11 wherein the compounds are halogen containing compounds.

13. The maximum/minimum thermometer according to claim 10 wherein the transfer liquid is a solution comprising ionic compounds.

14. The maximum/minimum thermometer according to claim 13 wherein the transfer liquid is a solution comprising at least one alkaline earth and/or alkali metal salt.

15. The maximum/minimum thermometer according to claim 14 wherein the solution is an aqueous solution in which said at least one alkaline earth and/or alkali metal salt is dissolved.

16. The maximum/minimum thermometer according to claim 15 wherein the aqueous solution comprises an amount of alkaline earth and/or alkali metal salt from between 80% and 400% w/v.

17. The maximum/minimum thermometer according to claim 16 wherein the alkaline earth or alkali metal salt is selected from halides, sulphates, hydroxides, carbonates, chlorates, dichromates, chromates, carboxylates, nitrates, nitrites, phosphates, ammonium compounds or other salts comprising an alkaline earth or alkali metal ion and a cationic species.

18. The maximum/minimum thermometer according to claim 17 wherein the alkali earth or alkali metal salt is selected from  $\text{CaI}_2$ ,  $\text{CaBr}_2$ ,  $\text{CsBr}$ ,  $\text{CsF}$ ,  $\text{CsOH}$ ,  $\text{Cs}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOC}_s$ ,  $\text{KF} \cdot 2\text{H}_2\text{O}$ ,  $\text{HCOOK}$ ,  $\text{KI}$ ,  $\text{KNO}_2$ ,  $\text{RbF}$ ,  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  and  $\text{NaI} \cdot 2\text{H}_2\text{O}$ .

19. The maximum/minimum thermometer according to any preceding claim wherein the expansion liquid comprises a hydrocarbon or mixtures of hydrocarbon.

20. The maximum/minimum thermometer according to any preceding claim wherein the indexes have a density less than that of the transfer liquid and are able to float at the surface of the transfer liquid.

21. The maximum/minimum thermometer according to claim 20 wherein the indexes are in the form of a tube into which has been inserted a piece of ferrous wire.

22. The maximum/minimum thermometer according to claim 20 wherein the indexes are constructed from a plastic material into which has been mixed and/or melted a quantity of magnetic powder such as iron filings, magnetite ( $\text{Fe}_3\text{O}_4$ ), strontium ferrite, or other magnetic powders.

23. A index for use in a maximum/minimum thermometer the index comprising a plastics material into which has been mixed and/or melted a quantity of a magnetic powder.

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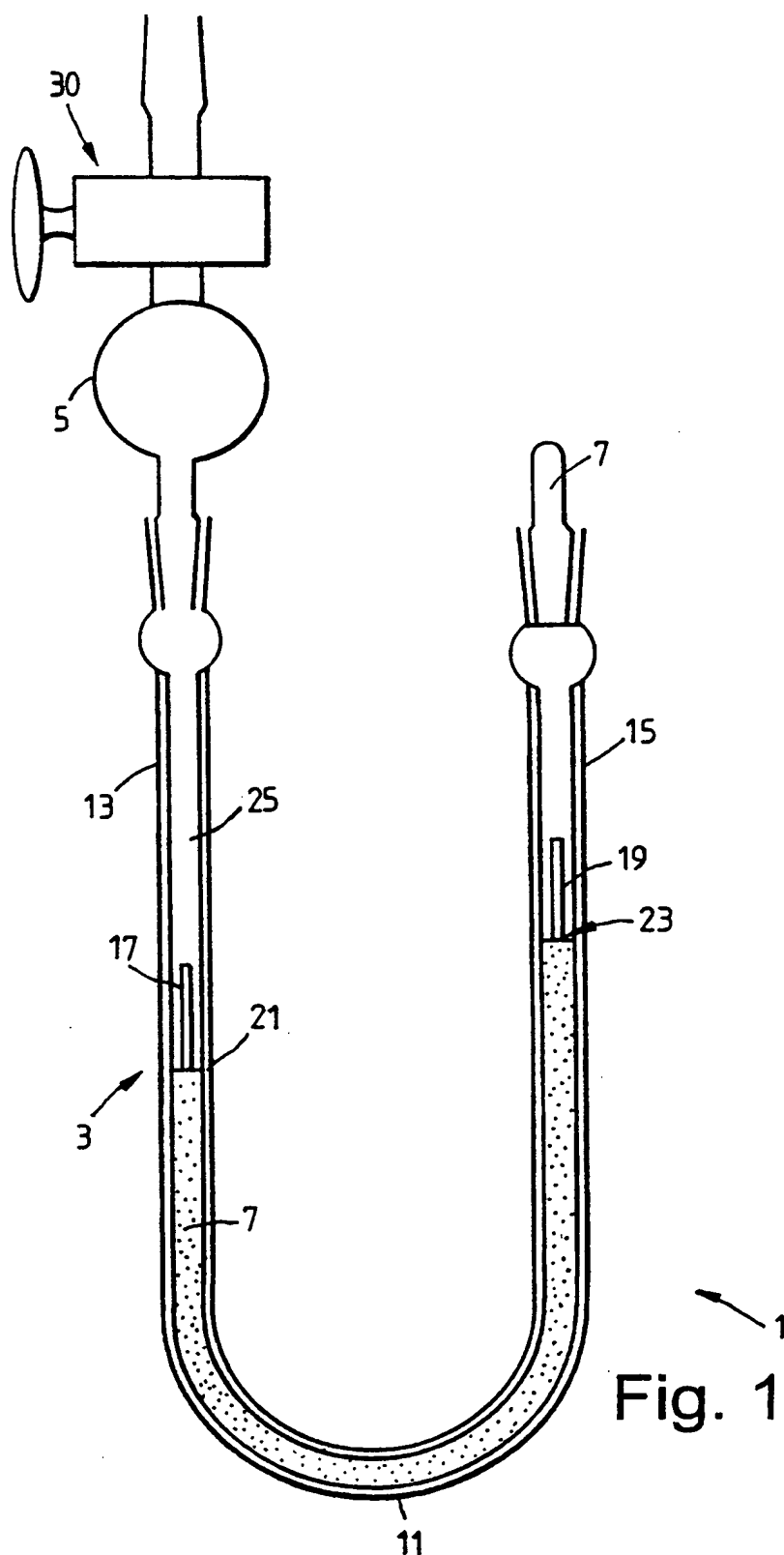


Fig. 1

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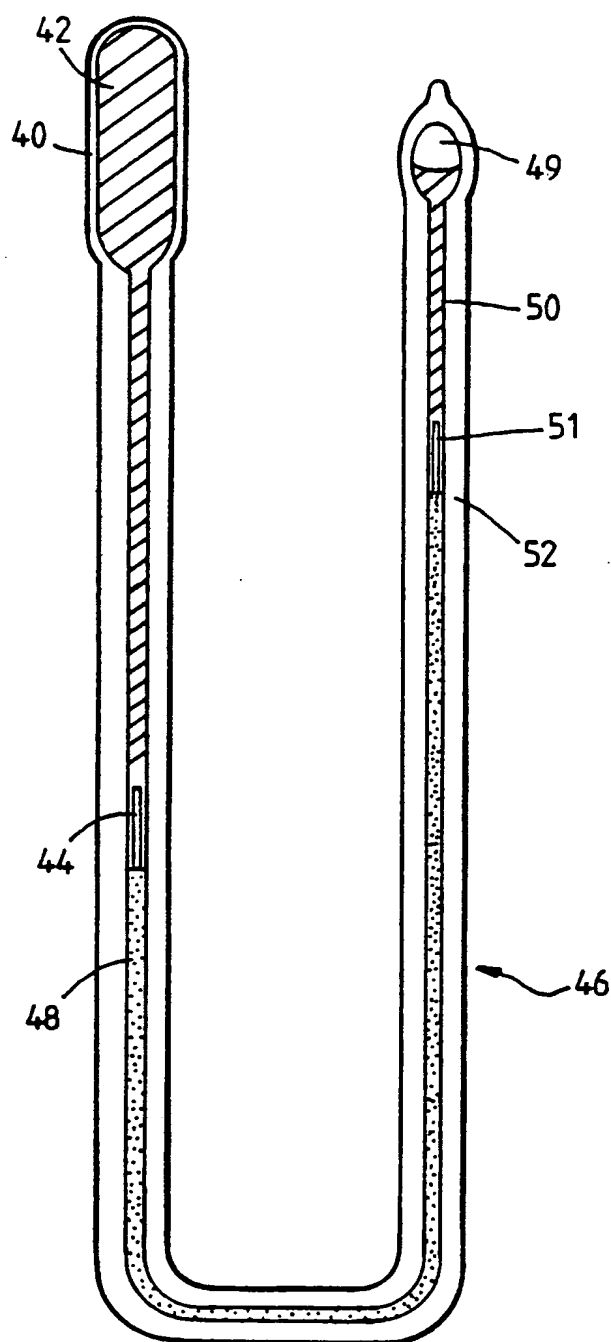


Fig. 2



## INTERNATIONAL RCH REPORT

Int. Application No

PCT/GB 00/00833

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G01K5/20

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 627 741 A (FALLER DAGMAR) 9 December 1986 (1986-12-09) cited in the application the whole document	1

☐ Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*Z\* document member of the same patent family

Date of the actual completion of the international search

2 May 2000

Date of mailing of the international search report

10/05/2000

Name and mailing address of the ISA

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Authorized officer

Ramboer, P

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int: Application No

PCT/GB 00/00833

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4627741 A	09-12-1986	DE 3433222 A	28-03-1985
		DE 3485721 A	17-06-1992
		EP 0141181 A	15-05-1985
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REPLACES  
ART 34 AMDT

000/54014

CT/GB00/00833

CLAIMS

1. A maximum/minimum thermometer comprising an expansion liquid which expands or contracts in response to changes in temperature, a transfer liquid which is substantially immiscible with the expansion liquid, and two indexes capable of being moved through action of the transfer or expansion liquid, wherein the transfer liquid is mercury free.

2. The maximum/minimum thermometer according to claim 1 wherein the transfer liquid has a density which is different from that of the expansion liquid.

3. The maximum/minimum thermometer according to claim 2 wherein the transfer liquid has a density greater than that of the expansion liquid.

4. The maximum/minimum thermometer according to claim 3 wherein the transfer liquid has a density greater than 0.87 g. cm<sup>-3</sup>.

5. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid remains in a substantially mobile state at and between the upper and lower temperature limits of the thermometer in use.

6. The maximum/minimum thermometer according to claim 5 wherein the transfer liquid remains substantially liquid at least between  $-30^{\circ}\text{C}$  and  $+50^{\circ}\text{C}$ .

5        7. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid further displays a low thermal expansivity; a low toxicity; and/or is coloured or capable of being coloured.

10       8. The maximum/minimum thermometer according to claim 7 wherein the transfer liquid is capable of being coloured by a suitable dye.

15       9. The maximum/minimum thermometer according to claim 8 wherein the dye is selected from Aniline Blue, Eurocert Green S or water soluble salts of inorganic complex ions such as the copper (II) (tetra-ammoniato) ion or the hexacyanatoferate ion.

20       10. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid is selected from solutions of inorganic or organometallic compounds; organic liquids; and ionic liquids.

11. The maximum/minimum thermometer according to claim 10 wherein the transfer liquid is a solution comprising inorganic or organometallic compounds of elements found in groups III, IV, V, VI and VII of the periodic table, or mixtures thereof.

12. The maximum/minimum thermometer according to claim 11 wherein the compounds are halogen containing compounds.

13. The maximum/minimum thermometer according to claim 10 wherein the transfer liquid is a solution comprising ionic compounds.

14. The maximum/minimum thermometer according to claim 13 wherein the transfer liquid is a solution comprising at least one alkaline earth and/or alkali metal salt.

15. The maximum/minimum thermometer according to claim 14 wherein the solution is an aqueous solution in which said at least one alkaline earth and/or alkali metal salt is dissolved.

16. The maximum/minimum thermometer according to claim 15 wherein the aqueous solution comprises an amount of alkaline earth and/or alkali metal salt from between 80% and 400% w/v.

17. The maximum/minimum thermometer according to claim 16 wherein the alkaline earth or alkali metal salt is selected from halides, sulphates, hydroxides, carbonates, chlorates, dichromates, chromates, carboxylates, nitrates, nitrites, phosphates, ammonium compounds or other salts comprising an alkaline earth or alkali metal ion and a cationic species.

18. The maximum/minimum thermometer according to claim 17 wherein the alkali earth or alkali metal salt is selected from  $\text{CaI}_2$ ,  $\text{CaBr}_2$ ,  $\text{CsBr}$ ,  $\text{CsF}$ ,  $\text{CsOH}$ ,  $\text{Cs}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOC}_2$ ,  $\text{KF} \cdot 2\text{H}_2\text{O}$ ,  $\text{HCOOK}$ ,  $\text{KI}$ ,  $\text{KNO}_2$ ,  $\text{RbF}$ ,  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  and  $\text{NaI} \cdot 2\text{H}_2\text{O}$ .

19. The maximum/minimum thermometer according to any preceding claim wherein the expansion liquid comprises a hydrocarbon or mixtures of hydrocarbon.

20. The maximum/minimum thermometer according to any preceding claim wherein the indexes have a density less than that of the transfer liquid and are able to float at the surface of the transfer liquid.

21. The maximum/minimum thermometer according to claim 20 wherein the indexes are in the form of a tube into which has been inserted a piece of ferrous wire.

22. The maximum/minimum thermometer according to claim 20 wherein the indexes are constructed from a plastic material into which has been mixed and/or melted a quantity of magnetic powder such as iron filings, magnetite ( $\text{Fe}_3\text{O}_4$ ), strontium ferrite, or other magnetic powders.

23. A index for use in a maximum/minimum thermometer the index comprising a plastics material into which has been mixed and/or melted a quantity of a magnetic powder.

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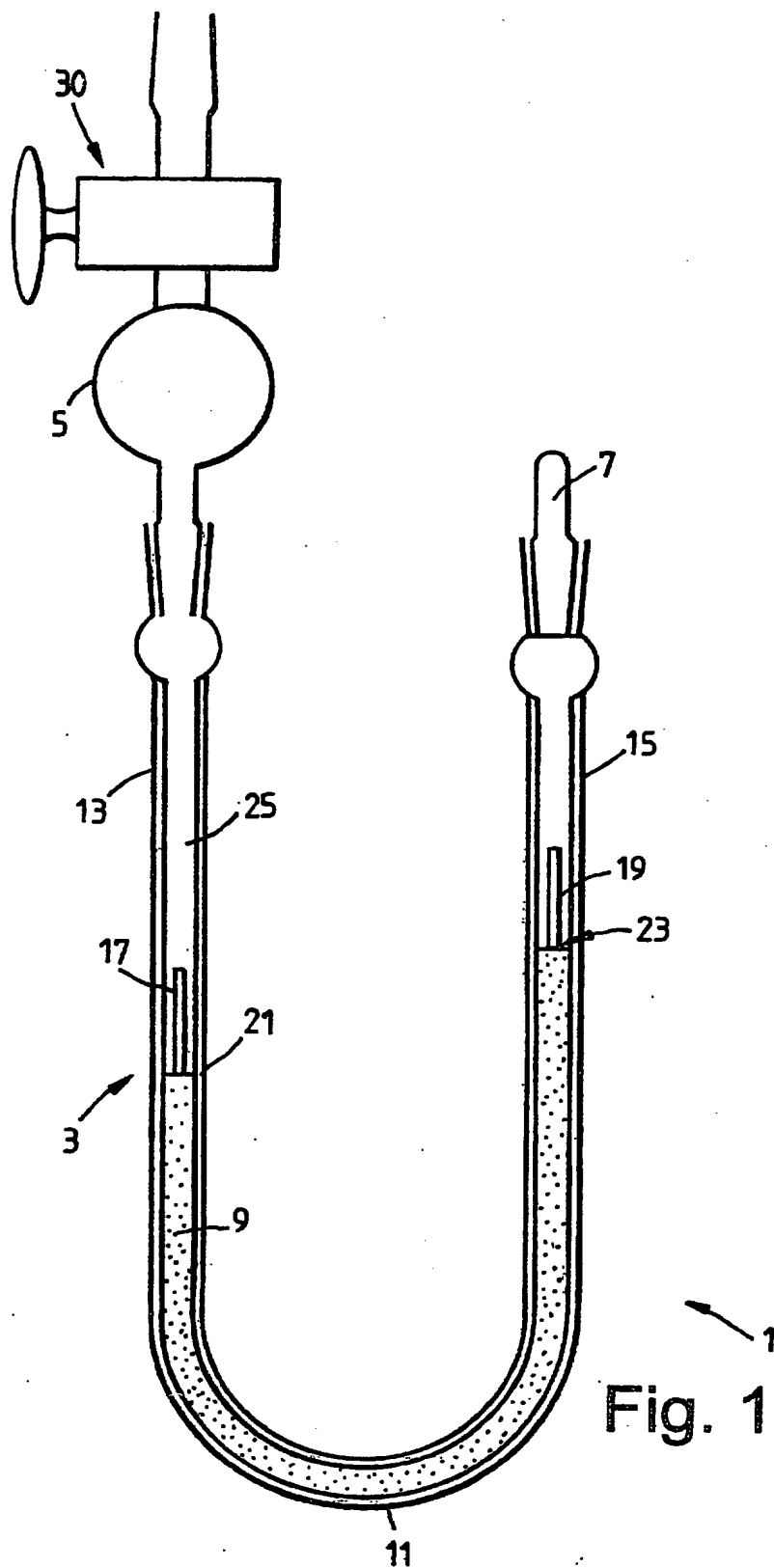


Fig. 1

09936387.121801



# PATENT COOPERATION TREATY

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

MCCALLUM, William P.  
CRUIKSHANK & FAIRWEATHER  
19 Royal Exchange Square  
Glasgow G1 3AE  
GRANDE BRETAGNE

PCT

## NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing

(day/month/year)

04.07.2001

Applicant's or agent's file reference

PC/SJB/P10449PC

### IMPORTANT NOTIFICATION

International application No.

PCT/GB00/00833

International filing date (day/month/year)

07/03/2000

Priority date (day/month/year)

09/03/1999

Applicant

S. BRANNAN & SONS LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

#### 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



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Fax: +49 89 2399 - 4465

Authorized officer

Weber, R



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# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC/SJB/P10449PC		FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB00/00833	International filing date (day/month/year) 07/03/2000	Priority date (day/month/year) 09/03/1999	
International Patent Classification (IPC) or national classification and IPC G01K5/20			
Applicant S. BRANNAN & SONS LTD. et al.			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 6 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input checked="" type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input type="checkbox"/> Certain documents cited</li> <li>VII <input type="checkbox"/> Certain defects in the international application</li> <li>VIII <input checked="" type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand  06/07/2000		Date of completion of this report  04.07.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer  Van der Goot, D  Telephone No. +49 89 2399 2562 	

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00833

**I. Basis of the report**

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17):* Description, pages:

1-22 as originally filed

**Claims, No.:**

1-22 as received on 25/05/2001 with letter of 23/05/2001

**Drawings, sheets:**

2/2 as originally filed

1/2 as received on 25/05/2001 with letter of 23/05/2001

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00833

- ☐ the description,      pages:  
☐ the claims,      Nos.:  
☐ the drawings,      sheets:
5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):  
*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*
6. Additional observations, if necessary:

**IV. Lack of unity of invention**

1. In response to the invitation to restrict or pay additional fees the applicant has:
- ☐ restricted the claims.  
☐ paid additional fees.  
☐ paid additional fees under protest.  
☐ neither restricted nor paid additional fees.
2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is
- ☐ complied with.  
☒ not complied with for the following reasons:  
**see separate sheet**
4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:
- ☒ all parts.  
☐ the parts relating to claims Nos. .

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)      Yes: Claims 1-22  
                         No: Claims

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/00833

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Inventive step (IS)	Yes:	Claims	1-22
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

Reference is made to the following document:

D1: US-A-4 627 741 (FALLER DAGMAR) 9 December 1986 (1986-12-09) cited in the application

#### Section IV

1. The application contains 2 independent claims 1 and 23 which **a priori** lack unity within the meaning of Rules 13.1, 13.2 and 13.3 PCT since the subject matter claimed in claim 1 at the one hand and claim 23 at the other hand constitute **two separate inventions**, which are not so linked as to form a single general inventive concept for the following reasons:

- 1.1 Independent **claim 1** relates to a maximum/minimum thermometer comprising a transfer liquid and two indexes capable of being moved through the action of the transfer liquid.

Independent **claim 22** relates to an index for use in a maximum/minimum thermometer and has the index as the only feature in common with claim 1.

- 1.2 Since this common feature is known from D1 (see indexes 11 and 12 in figure 1), it does not contribute to inventive step of the claimed subject matter. Starting from D1, the following "special technical features" as defined in Rule 13.2 PCT are to be considered in making a contribution over this prior art:

In claim 1 the provision of a transfer liquid which is mercury free.

In claim 22 the index comprising a plastics material into which has been mixed and/or melted a quantity of magnetic powder.

The technical problems to be solved by these features are:

With respect to claim 1 the problem of avoiding the use of a toxic medium such as mercury.

With respect to claim 22 the provision of an alternative material for the magnetically attractable indexes.

- 1.3 From the above analysis it follows that the problems underlying the subject matter

of claim 1 at the one hand and that of claim 22 at the other hand are quite different and not related to each other as are the features associated with the solutions of these problems. Therefore, the technical relationship between the subject matter of claim 1 at the one hand and that of claim 22 at the other hand as required by Rule 13.2 PCT is lacking and the requirement for unity of invention pursuant to Rule 13.1 is not fulfilled.

### Section V

1. The invention relates to a maximum/minimum thermometer comprising a transfer liquid and an expansion liquid and independent claims 1 and 22 start from US-A-4627741 (D1) as closest prior art.
2. The thermometer defined in claim 1 differs from the conventional thermometer of D1, and therefore satisfies the requirement of novelty (Art. 33(2) PCT), in that the **transfer liquid** in the thermometer is mercury free, thus avoiding the use of a toxic medium in the thermometer and its detrimental effects upon breakage of the thermometer.  
The index defined in claim 22 differs from the index disclosed in D1, and therefore satisfies the requirement of novelty (Art. 33(2) PCT), in that it comprises a plastics material into which has been mixed and/or melted a quantity of magnetic powder, thus enabling an easy way of manufacture suitable for mass production.
3. The subject matter of claims 1 and 22 also satisfies the requirements of inventive step (Art. 33(3) PCT), since the sole document available from the international search report, which discloses the use of mercury as the transfer liquid and an index made of glass having a magnetically attractable pin hot-molten therewith, does not in any way hint at the possibility of using a mercury free transfer liquid or an index comprising a plastics material into which has been mixed and/or melted a quantity of magnetic powder, nor is there any mention of the problems as mentioned above under paragraph 2. The skilled person, therefore, finds no indication in D1 which would lead him the subject matter defined in claims 1 and 22 of the present application without any inventive effort.

4. The industrial applicability (Art. 33(4) PCT) of the claimed subject matter is beyond doubt.
5. Novelty, inventive step and industrial applicability of the dependent claims 2-21 follow from the dependency of these claims on the independent claim 1.

### **Section VIII**

#### **1. Objections under Article 6 PCT**

The density of the transfer liquid being different from (cf. claim 2) and in particular being greater than that of the expansion liquid (cf claim 3), as well as the density of the index being less than that of the transfer liquid (cf claim 19) appear to be essential features for the performance of the thermometer set out in claim 1. To the extent that claim 1 does not include these features the claim is not clear.



## CLAIMS

1. A maximum/minimum thermometer comprising an expansion liquid (42) which expands or contracts in response to changes in temperature, a transfer liquid (48) which is moved in response to the expansion or contraction of the expansion liquid and which is substantially immiscible with the expansion liquid, and two indexes (44, 51) capable of being moved through action of the transfer or expansion liquid, wherein the transfer liquid is mercury free.
2. The maximum/minimum thermometer according to claim 1 wherein the transfer liquid has a density which is different from that of the expansion liquid.
3. The maximum/minimum thermometer according to claim 2 wherein the transfer liquid has a density greater than that of the expansion liquid.
4. The maximum/minimum thermometer according to claim 3 wherein the transfer liquid has a density greater than  $0.87 \text{ g. cm}^{-3}$ .
5. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid remains substantially liquid at least between  $-30^{\circ}\text{C}$  and  $+50^{\circ}\text{C}$ .

6. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid further displays a low thermal expansivity; a low toxicity; and/or is coloured or capable of being coloured.

5

7. The maximum/minimum thermometer according to claim 6 wherein the transfer liquid is capable of being coloured by a suitable dye.

10

8. The maximum/minimum thermometer according to claim 7 wherein the dye is selected from Aniline Blue, Eurocert Green S or water soluble salts of inorganic complex ions such as the copper (II) (tetra-ammoniato) ion or the hexacyanato ferrate ion.

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9. The maximum/minimum thermometer according to any preceding claim wherein the transfer liquid is selected from solutions of inorganic or organometallic compounds; organic liquids; and ionic liquids.

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10. The maximum/minimum thermometer according to claim 9 wherein the transfer liquid is a solution comprising inorganic or organometallic compounds of elements found in groups III, IV, V, VI and VII of the periodic table, or mixtures thereof.

25

11. The maximum/minimum thermometer according to claim 10 wherein the compounds are halogen containing

compounds.

12. The maximum/minimum thermometer according to claim 9  
wherein the transfer liquid is a solution comprising  
5 ionic compounds.

13. The maximum/minimum thermometer according to claim 12  
wherein the transfer liquid is a solution comprising  
at least one alkaline earth and/or alkali metal salt.

14. The maximum/minimum thermometer according to claim 13  
wherein the solution is an aqueous solution in which  
said at least one alkaline earth and/or alkali metal  
salt is dissolved.

15. The maximum/minimum thermometer according to claim 14  
wherein the aqueous solution comprises an amount of  
alkaline earth and/or alkali metal salt from between  
80% and 400% w/v.

16. The maximum/minimum thermometer according to claim 15  
wherein the alkaline earth or alkali metal salt is  
selected from halides, sulphates, hydroxides,  
carbonates, chlorates, dichromates, chromates,  
25 carboxylates, nitrates, nitrites, phosphates, ammonium  
compounds or other salts comprising an alkaline earth  
or alkali metal ion and a cationic species.

17. The maximum/minimum thermometer according to claim 16 wherein the alkali earth or alkali metal salt is selected from  $\text{CaI}_2$ ,  $\text{CaBr}_2$ ,  $\text{CsBr}$ ,  $\text{CsF}$ ,  $\text{CsOH}$ ,  $\text{Cs}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOC}_a$ ,  $\text{KF} \cdot 2\text{H}_2\text{O}$ ,  $\text{HCOOK}$ ,  $\text{KI}$ ,  $\text{KNO}_2$ ,  $\text{RbF}$ ,  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  and  $\text{NaI} \cdot 2\text{H}_2\text{O}$ .
18. The maximum/minimum thermometer according to any preceding claim wherein the expansion liquid comprises a hydrocarbon or mixtures of hydrocarbon.
19. The maximum/minimum thermometer according to any preceding claim wherein the indexes have a density less than that of the transfer liquid and are able to float at the surface of the transfer liquid.
20. The maximum/minimum thermometer according to claim 19 wherein the indexes are in the form of a tube into which has been inserted a piece of ferrous wire.
21. The maximum/minimum thermometer according to claim 19 wherein the indexes are constructed from a plastic material into which has been mixed and/or melted a quantity of magnetic powder such as iron filings, magnetite ( $\text{Fe}_3\text{O}_4$ ), strontium ferrite, or other magnetic powders.
22. A index for use in a maximum/minimum thermometer the index comprising a plastics material into which has

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been mixed and/or melted a quantity of a magnetic powder.

5

1/2

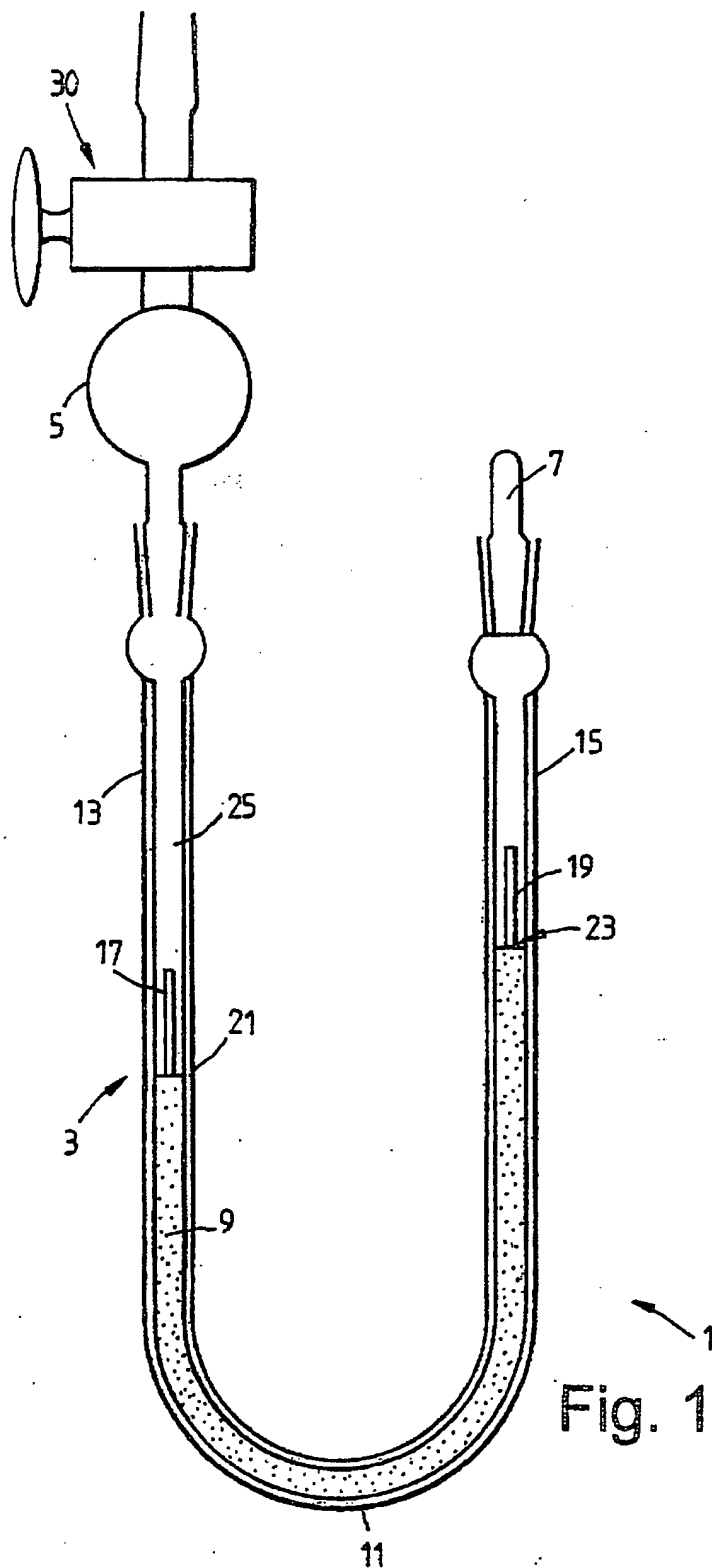


Fig. 1

REC'D 06 JUL 2001

WIPO PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC/SJB/P10449PC	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/00833	International filing date (day/month/year) 07/03/2000	Priority date (day/month/year) 09/03/1999
International Patent Classification (IPC) or national classification and IPC G01K5/20		
Applicant S. BRANNAN & SONS LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 7 sheets, including this cover sheet.

- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☒ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand  06/07/2000	Date of completion of this report  04.07.2001
Name and mailing address of the international preliminary examining authority:   European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer  Van der Goot, D  Telephone No. +49 89 2399 2562 

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00833

## I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

**Description, pages:**

1-22 as originally filed

**Claims, No.:**

1-22 as received on 25/05/2001 with letter of 23/05/2001

**Drawings, sheets:**

2/2 as originally filed

1/2 as received on 25/05/2001 with letter of 23/05/2001

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:



# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00833

- ☐ the description,      pages:
- ☐ the claims,      Nos.:
- ☐ the drawings,      sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

## IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

- ☐ restricted the claims.
- ☐ paid additional fees.
- ☐ paid additional fees under protest.
- ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

- ☐ complied with.
- ☒ not complied with for the following reasons:  
**see separate sheet**

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

- ☒ all parts.
- ☐ the parts relating to claims Nos. .

## V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-22
	No:	Claims	

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00833

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Inventive step (IS)	Yes:	Claims	1-22
	No:	Claims	

Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

## VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

Reference is made to the following document:

D1: US-A-4 627 741 (FALLER DAGMAR) 9 December 1986 (1986-12-09) cited in the application

#### **Section IV**

1. The application contains 2 independent claims 1 and 23 which **a priori** lack unity within the meaning of Rules 13.1, 13.2 and 13.3 PCT since the subject matter claimed in claim 1 at the one hand and claim 23 at the other hand constitute **two separate inventions**, which are not so linked as to form a single general inventive concept for the following reasons:

- 1.1 Independent **claim 1** relates to a maximum/minimum thermometer comprising a transfer liquid and two indexes capable of being moved through the action of the transfer liquid.

Independent **claim 22** relates to an index for use in a maximum/minimum thermometer and has the index as the only feature in common with claim 1.

- 1.2 Since this common feature is known from D1 (see indexes 11 and 12 in figure 1), it does not contribute to inventive step of the claimed subject matter. Starting from D1, the following "special technical features" as defined in Rule 13.2 PCT are to be considered in making a contribution over this prior art:

In claim 1 the provision of a transfer liquid which is mercury free.

In claim 22 the index comprising a plastics material into which has been mixed and/or melted a quantity of magnetic powder.

The technical problems to be solved by these features are:

With respect to claim 1 the problem of avoiding the use of a toxic medium such as mercury.

With respect to claim 22 the provision of an alternative material for the magnetically attractable indexes.

- 1.3 From the above analysis it follows that the problems underlying the subject matter

of claim 1 at the one hand and that of claim 22 at the other hand are quite different and not related to each other as are the features associated with the solutions of these problems. Therefore, the technical relationship between the subject matter of claim 1 at the one hand and that of claim 22 at the other hand as required by Rule 13.2 PCT is lacking and the requirement for unity of invention pursuant to Rule 13.1 is not fulfilled.

### **Section V**

1. The invention relates to a maximum/minimum thermometer comprising a transfer liquid and an expansion liquid and independent claims 1 and 22 start from US-A-4627741 (D1) as closest prior art.
2. The thermometer defined in claim 1 differs from the conventional thermometer of D1, and therefore satisfies the requirement of novelty (Art. 33(2) PCT), in that the **transfer liquid** in the thermometer is mercury free, thus avoiding the use of a toxic medium in the thermometer and its detrimental effects upon breakage of the thermometer.  
The index defined in claim 22 differs from the index disclosed in D1, and therefore satisfies the requirement of novelty (Art. 33(2) PCT), in that it comprises a plastics material into which has been mixed and/or melted a quantity of magnetic powder, thus enabling an easy way of manufacture suitable for mass production.
3. The subject matter of claims 1 and 22 also satisfies the requirements of inventive step (Art. 33(3) PCT), since the sole document available from the international search report, which discloses the use of mercury as the transfer liquid and an index made of glass having a magnetically attractable pin hot-molten therewith, does not in any way hint at the possibility of using a mercury free transfer liquid or an index comprising a plastics material into which has been mixed and/or melted a quantity of magnetic powder, nor is there any mention of the problems as mentioned above under paragraph 2. The skilled person, therefore, finds no indication in D1 which would lead him the subject matter defined in claims 1 and 22 of the present application without any inventive effort.

4. The industrial applicability (Art. 33(4) PCT) of the claimed subject matter is beyond doubt.
5. Novelty, inventive step and industrial applicability of the dependent claims 2-21 follow from the dependency of these claims on the independent claim 1.

### **Section VIII**

#### **1. Objections under Article 6 PCT**

The density of the transfer liquid being different from (cf. claim 2) and in particular being greater than that of the expansion liquid (cf claim 3), as well as the density of the index being less than that of the transfer liquid (cf claim 19) appear to be essential features for the performance of the thermometer set out in claim 1. To the extent that claim 1 does not include these features the claim is not clear.

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>MGH/PC/P10449PC</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 00833</b>	International filing date (day/month/year) <b>07/03/2000</b>	(Earliest) Priority Date (day/month/year) <b>09/03/1999</b>
Applicant <b>S. BRANNAN &amp; SONS LTD. et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

### 1. Basis of the report

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of Invention is lacking (see Box II).

### 4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

### 5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawing to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1  
☐ Non of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No

GB 00/00833

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 G01K5/20

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 627 741 A (FALLER DAGMAR) 9 December 1986 (1986-12-09) cited in the application the whole document -----	1



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

2 May 2000

Date of mailing of the international search report

10/05/2000

Name and mailing address of the ISA

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Authorized officer

Ramboer, P

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/00833

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4627741 A	09-12-1986	DE 3433222 A	28-03-1985
		DE 3485721 A	17-06-1992
		EP 0141181 A	15-05-1985
<hr/>			